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BULLETIN OF THE TORREY BOTANICAL CLUB

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THE MEIOTIC BEHAVIOR OF HEXAPLOID ORCHARD GRASS (DACTYLIS GLOMERATA L.)[1]

A. A. HANSON AND HELEN D. HILL[2]

Hexaploid plants of *Dactylis glomerata* L. isolated from open pollinated collections, were preserved in order to determine their practical value in orchard grass improvement. The advantages that a hexaploid strain might possess from the standpoint of yield and isolation for seed production merit investigation, even though increased difficulties may be encountered in recombining desirable agronomic characters.

Preliminary studies indicated that the hexaploids were characterized by a relatively high degree of instability at meiosis. A more detailed examination was therefore undertaken to study the nature and extent of this irregularity. Data were also obtained on the occurrence of aneuploidy in the progenies from hexaploid plants.

Materials and methods. In the spring of 1948 twenty-four hexaploid plant selections were multiplied vegetatively and established as 15 single plant replications in a polycross nursery. The nursery was not isolated from plantings of tetraploid orchard grass. In 1949 samples were collected for cytological study and seed was harvested for plot tests. Material collected for cytological study was fixed in three parts absolute alcohol: one part glacial acetic acid, and stored in the fixing solution at 20 degrees F. Meiosis was studied in pollen mother cell smears made with acetocarmine.

From 10 plants data were collected on chromosome behavior at diakinesis, metaphase I, anaphase I and on the frequency of quartets with micronuclei. Duplicate heads from each of four additional plants were studied at diakinesis and the quartet stage. Open pollinated seed was used to establish 15 seedlings from each of 12 plants, representing duplicate samples of six different clones. Chromosome counts were made using the root-tip technique described by Hill and Myers (1945).

Data for making comparisons with tetraploid behavior were obtained from 13 plants derived from crosses involving a tetraploid parent identified as possessing a reciprocal translocation. Additional data on the meiosis of open pollinated and inbred tetraploid plants were available in published reports of Myers and Hill (1943) and Myers (1943).

[1] Contribution No. 110 of the U. S. Regional Pasture Research Laboratory, Division of Forage Crops and Diseases, Bureau of Plant Industry, Soils and Agricultural Engineering, Agricultural Research Administration, U. S. Department of Agriculture, State College, Pennsylvania, in cooperation with the twelve Northeastern States.

[2] Agent and Assistant Geneticist, respectively.

[THE BULLETIN for January–February (80: 1–112) was issued January 26, 1953]

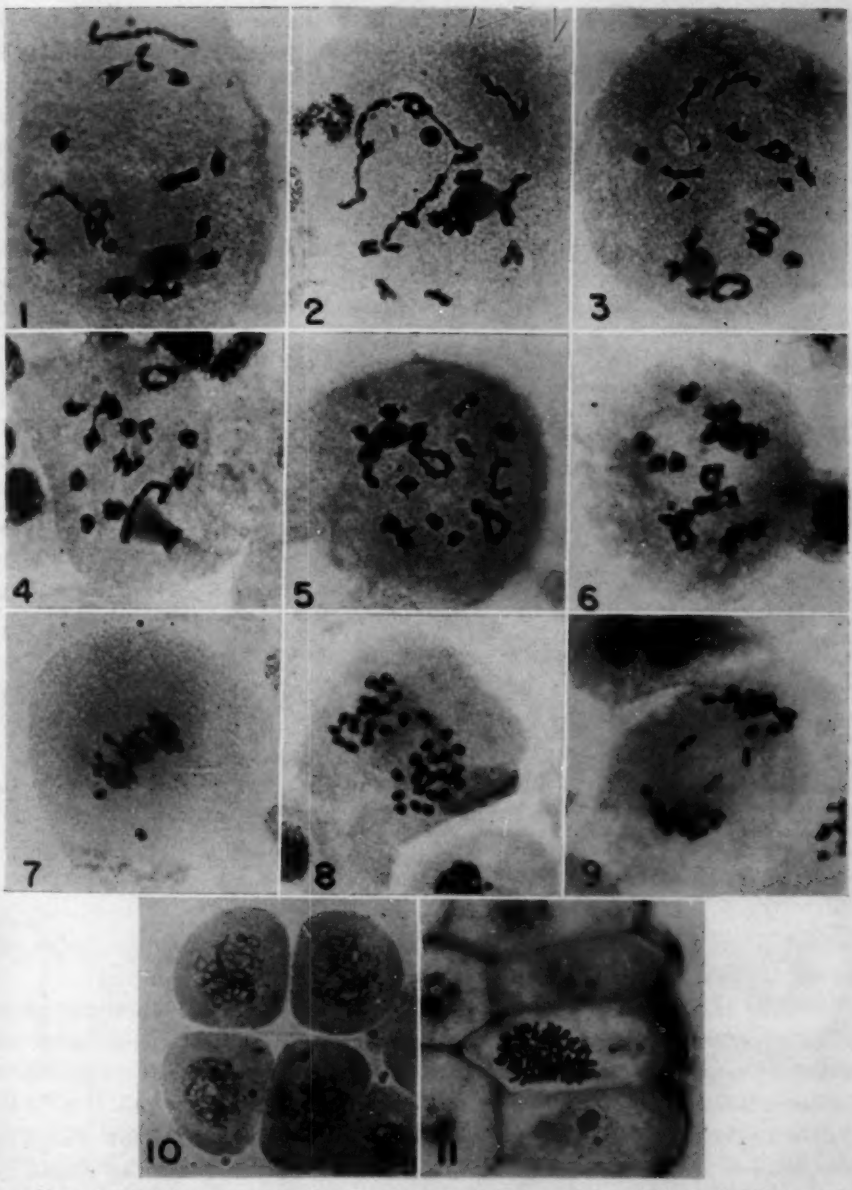
Experimental results. Meiosis in hexaploid orchard grass. An average of 29 sporocytes per plant was examined at diakinesis. The average number of quadrivalents per sporocyte was 2.57, with a range of 1.66 to 3.01, while the average number of multivalent configurations was 3.41, with a range of 2.36 to 4.04. Most of these higher associations were hexavalents, although occasional octavalents were observed in some plants and in one sporocyte a chain of ten was recorded. Trivalents and quintavalents occurred infrequently.

Figures 1 to 10 illustrate some of the meiotic irregularities encountered in hexaploids. Figures 1 to 6 were selected to illustrate one of the problems involved in the interpretation of diakinesis. Although the majority of the multivalent associations observed in this material were well defined (figs. 5 and 6), the interpretation was complicated in some sporocytes by the presence of thin chromatin threads connecting two or more chromosomes. In general, the orientation of the chromosomes would make it difficult to conceive that the continuity of these threads resulted from crossing over. This is well illustrated by the thin chromatin thread joining three of the chromosome pairs in figure 4. In a number of sporocytes, however, the orientation of the chromatin threads and the chromosomes, suggests that chiasmata were involved in the origin of the connecting strands (figs. 1–3). The multivalent associations in figures 1 to 6 are as follows: (1) two quadrivalents and two hexavalents; (2) one octavalent; (3) four quadrivalents; (4) two quadrivalents; (5) two quadrivalents and one hexavalent; and (6) two quadrivalents and one hexavalent.

The average number of half chiasmata per chromosome was 1.66 with a range of 1.52 to 1.77, while unpaired chromosomes at diakinesis averaged 0.90 per cent, with a range of 0.14 to 2.73 per cent. Typical irregularities at metaphase I, anaphase I and telophase II, are shown in figures 7 to 10. In figure 7 the arrangement of the two univalents at metaphase I suggests that they may have arisen from precocious disjunction. Figure 8 shows a 20–21 separation at anaphase I with one lagging and dividing univalent, while three laggards can be seen in figure 9. A quartet with six micronuclei is shown in figure 10. Metaphase I univalents were positively associated with anaphase I laggards, which in turn were positively correlated with the percentage of quartets with micronuclei ($r = 0.79$).

Comparisons between hexaploid and tetraploid orchard grass. Selected features of meiotic behavior in hexaploid and tetraploid orchard grass are summarized in Table 1. The experiments were conducted in different years, but all of the plant material was grown in the field except the reciprocal translocation progenies which were grown in the greenhouse.

The frequency of chiasmata in the hexaploids was similar to that recorded for inbred line 2(3), by Myers and Hill (1943). Their interpreta-



FIGS. 1–11. Photomicrographs of aceto-carmine smear preparations of pollen mother cells in hexaploid orchard grass. Magnification × 800. FIGS. 1–6. Early to late diakinesis. FIG. 7. Metaphase I. FIG. 8. Anaphase I. FIG. 9. Late anaphase I. FIG. 10. Telophase II. FIG. 11. Somatic cell. $2n = 70$.

tion indicated that inbreeding results in a lower chiasma frequency in some families, but not in others. The average number of half chiasmata in the remaining tetraploid collections, shown in table 1 was appreciably higher than in the hexaploids.

All of the hexaploids had a small but consistent percentage of unpaired chromosomes at diakinesis. Similarly, 18 of the 20 plants in inbred line 2(3), had univalents at diakinesis. An occasional univalent was observed in the open pollinated and reciprocal translocation collections, but for all practical purposes synapsis was complete. The most irregular plant in the open pollinated collection (55.6 per cent of the quartets with micro-

TABLE 1. *Summary for selected features of diakinesis and percentage of quartets with micronuclei in hexaploid and tetraploid orchard grass*

	HEXAPLOID	TETRAPLOID		
		(a) Inbred line, 2 (3)	Reciprocal Translocation	(b) Open Pollinated Selections
Number of plants	14	20	13	9
Av. number of sporocytes	29	20	22	24
Av. number of half chiasmata	1.66 ± 0.02	1.70 ± 0.03	1.78 ± 0.02	1.80 ± 0.02
Range	1.52 – 1.77	1.35 – 1.90	1.66 – 1.93	1.69 – 1.90
Av. per cent unpaired chromosomes	0.90 ± 0.17	1.69 ± 0.58		
Range	0.14 –2.73	0.00 – 11.79		
Av. number of quadrivalents	2.57 ± 0.10	3.50 ± 0.12	1.75 ± 0.10	3.53 ± 0.17
Range	1.66 – 3.01	2.62 – 4.56	0.88 – 2.22	3.03 – 4.27
Av. number of multivalents	3.41 ± 0.12		2.00 ± 0.17	
Range	2.36 – 4.04		0.88 – 3.25	
Av. number of quartets	156	112	206	169
Av. per cent with micronuclei	42.6 ± 3.3	52.4 ± 5.4	13.8 ± 3.8	19.2 ± 5.6
Range	25.4 – 62.7	21.0 – 98.5	0.0 – 47.2	2.4 – 55.6

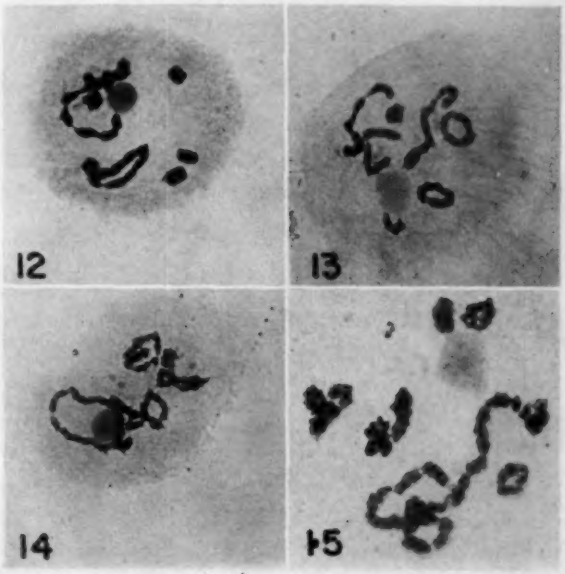
(a) *After Myers and Hill (1943)*
(b) *After Myers (1943)*

nuclei) proved to be an exception, since a number of univalents were observed at diakinesis (0.70 per cent of the chromosomes not paired).

One of the significant features of meiosis in tetraploid orchard grass is the presence of multivalents at diakinesis. The highest chromosome associations reported for open pollinated selections of orchard grass and their first generation inbred progenies are quadrivalents (Myers and Hill 1940, 1943 and Myers 1943). Reciprocal translocations, however, may result in the presence of hexavalent configurations in certain crosses, as shown in figures 12 to 15. The following multivalent configurations are evident in these representative sporocytes: figure 12, two hexavalents; figure 13, four quadrivalents; figure 14, one hexavalent; figure 15, one hexavalent and one quadrivalent.

In hexaploid plants hexavalent configurations were relatively common

and higher associations were occasionally observed. The average number of multivalents was quite similar to the average number of quadrivalents reported for tetraploid collections (Table 1). On the other hand, the average number of multivalents found in the reciprocal translocation collection was exceptionally low. This material was grown in the greenhouse under very different environmental conditions. While the percentage of quartets with micronuclei was of the same order in the hexaploids as in the inbred tetraploid 2(3), in general, the reciprocal translocation progenies and the open pollinated selections showed greater stability in their smaller percentages of quartets with micronuclei.



FIGS. 12–15. Diakinesis in F_1 plants from cross involving a reciprocal translocation. FIGS. 12–14. Magnification × 800. FIG. 15. Magnification × 1200.

Considerable information is available on the degree of association among meiotic irregularities in tetraploid orchard grass. In order to obtain comparable information for hexaploids, chiasma frequency, multivalent frequency, and univalents at diakinesis, were correlated with the percentage of quartets with micronuclei. The presence of micronuclei at telophase II serves as a good criterion of meiotic regularity (Myers and Powers 1938) and can be determined with a high degree of accuracy (fig. 10).

The correlation coefficients presented in table 2 show that the interrelationships among meiotic irregularities in hexaploid plants correspond very well with those obtained in tetraploids. A significant negative correlation was obtained between percentage of quartets with micronuclei

and average number of half chiasmata in both the hexaploid and the reciprocal translocation collections. The partial correlation coefficients for micronuclei in the quartets and chiasma frequency independent of multivalent frequency (r12.3) were negative for all collections and significant in four of them.

The relationship between micronuclei in the quartets and the average number of multivalents (r13) was not significant except in inbred line 2(3), where a significant negative correlation coefficient was obtained. The partial

TABLE 2. *Simple, partial, and multiple correlation coefficients between selected features of diakinesis and percentage of quartets with micronuclei, in hexaploid and tetraploid orchard grass.*

	HEXAPLOID	TETRAPLOID			
Correlation Coefficients		(a) Inbred Line, 2(3)	(b) Inbred Line, 48(48)	Reciprocal Translocation	(c) Open Pollinated Selection
r12	−0.615*	−0.658**	−0.19	−0.612*	−0.615
r13	−0.220	−0.466*	+0.23	+0.326	+0.106
r14	+0.684**	+0.664**			
r23	+0.709**	+0.654**	+0.68	+0.002	+0.524
r24	−0.909**	−0.850**			
r34	−0.686**	−0.504*			
r12.3	−0.667*	−0.527*	−0.485	−0.647*	−0.792*
r12.4	+0.021	−0.237			
r13.2	+0.388	−0.063	+0.499	+0.413	+0.638
R1.23	0.687*	0.659**	0.526	0.693*	0.794
R1.234	0.769*	0.691*			
Number of Plants	14	20	6	13	9

(1) *percentage of quartets with micronuclei*
(2) *av. number of half chiasmata*
(3) *av. number of multivalents (refer specifically to quadrivalents in a, b and c)*
(4) *percentage of chromosomes not paired at diakinesis*
(*a and b*) *after Myers and Hill (1943)*
(c) *after Myers (1943)*
(*a and c*) *correlation coefficients recalculated. Slight differences in size can be accounted for by the number of places that have been carried forward after the decimals.*
* *significant at the five per cent level;* ** *significant at the one per cent level.*

correlation coefficients for micronuclei in the quartets and multivalent frequency independent of chiasma frequency (r13.2) were not significant. It is interesting to note, however, that they all show a definite positive trend with the exception of inbred line 2(3). The reciprocal translocation material provided the only exception to the positive association between chiasma frequency and multivalent frequency.

The correlation coefficients (r14) for the percentage of chromosomes not paired at diakinesis and the percentage of quartets with micronuclei

were positive and highly significant in both of the collections where they could be calculated. Similarly, the percentage of unpaired chromosomes was negatively correlated with chiasma (r24) and multivalent frequency (r34). The partial correlation coefficients for micronuclei in the quartets and chiasma frequency independent of the unpaired chromosomes at diakinesis (r12.4) were small and non-significant.

The multiple correlation coefficients indicate, that of the characters studied, chiasma frequency shows the closest relationships to percentage of quartets with micronuclei. The results for inbred line 48(48) suggest that multivalent frequency may have been equally as important in this sample, but the sample was small and the correlation coefficients were not significant.

TABLE 3. *Chromosome numbers of seedlings grown from open pollinated seed of hexaploid orchard grass.*

Progeny Number	Plant Number	Seedlings Examined	Chromosome Number								
			42	39	38	36	35	33	32	31	28
2	1373(2)	15	15								
2	1381(3)	15	15								
4	1391(1)	15	13				1	1			
4	1400(2)	15	12				3				
5	1381(8)	15	11				1		1	1	1
5	1400(4)	15	9	1		1	4				
7	1390(7)	15	10				5				
7	1400(5)	14	11			2	1				
11	1374(1)	15	15								
11	1384(3)	14	14								
20	1375(6)	15	13	1							1
20	1382(2)	15	14		1						
Total		178	152	2	1	3	15	1	1	1	2

Aneuploidy in hexaploid progenies. Chromosome counts of seedlings grown from open pollinated seed produced on two plants from each of six different hexaploid progenies are presented in table 3. Figure 11 is a photomicrograph of a cell with 70 chromosomes in an aneuploid with 2n = 35. Variations from the hexaploid number probably arose in one of the following ways: (a) fertilization of a haploid egg (n = 21) with pollen (n =14) from adjacent tetraploids, which would give the second predominant class, 2n = 35; (b) fertilization of aneuploid female gametes with pollen from euploid plants, n = 21 or 14; and (c) union of two aneuploid gametes. All of the plants reported with the exception of the 42 and 35 chromosome classes must have involved at least one and possibly two aneuploid gametes.

A total of 26 plants or 14.6 per cent of the sample varied from the expected chromosome complement (2n = 42) while the frequency of

aneuploids in the individual progenies varied from 0.0 to 33.3 per cent. As most of the 35 chromosome class probably resulted from the union of reduced eggs (n = 21) with pollen from adjacent tetraploids (n =14), it is possible that only 6.2 per cent of the plants involved the union of one or more aneuploid gametes. Similarly, if one assumes that diploid pollen was involved in the production of all plants having 35 chromosomes or less, then at least 11.2 per cent of the seedlings arose from intercrossing with tetraploid material.

Discussion. The meiotic behavior of hexaploid *Dactylis glomerata* L. adds further evidence in support of the autoploid nature of the original tetraploids. Although tetraploid orchard grass behaves genetically and cytologically like an autoploid (Myers 1941) two closely related species might have been involved in its origin. Under these circumstances the genomes contributed by the two species must have been relatively similar. The hexaploids considered in this study probably arose from the union of unreduced and reduced gametes. This assumption is supported by the common types of chromosome association that were encountered: bivalents and quadrivalents, and bivalents, quadrivalents and hexavalents. Higher associations could have arisen in several different ways, e.g. octavalents might involve reciprocal translocations.

Myers (1943) concluded that the number of quadrivalents in tetraploid plants is conditioned by (a) the number of chiasmata and (b) the amount of chromosomal differentiation. It is of interest to note that the multivalent frequency in hexaploids does not vary appreciably from the quadrivalent frequencies observed in tetraploids. The low multivalent frequency which was found in the tetraploid progenies, distinguished by the presence of a reciprocal translocation, may be partially accounted for by environmental conditions. After studying the quadrivalent frequency of six orchard grass clones over a two year period, Myers (1943) found that the effect of years was not significant, while the interaction of clones by years was highly significant.

The average number of chiasmata per chromosome proved to be more important than multivalent frequency in conditioning subsequent irregularities. This is in accord with the conclusions of Myers and Hill (1943) and Myers (1943). The results suggest, however, that the effect of multivalent frequency on meiotic stability may be greater when multivalent frequency is not accompanied by a corresponding increase in chiasma frequency. In the one collection (tetraploids with reciprocal translocation) where this supposition could be examined, the correlation between quartets with micronuclei and multivalent frequency was positive but not significant ($r13 = 0.326$).

In hexaploids and some inbred lines of orchard grass, low chiasma frequency is closely associated with the appearance of univalents at diakinesis. This relationship was not apparent in other collections of tetraploid orchard grass. In all populations, however, low chiasma frequency was accompanied by an increased proportion of open bivalents and chain multivalents. Correlation coefficients computed from data provided by Myers and Hill (1943) are of interest in regard to this relationship. Results obtained from a heterogeneous sample (53 plants, including replicated open pollinated selections and first generation inbreds) were grouped in a frequency distribution based on a five per cent interval for quartets with micronuclei. The correlation between chiasma frequency and quartets with micronuclei was negative and highly significant ($r = -0.81$), and the correlation for percentage of closed quadrivalents and quartets with micronuclei was also negative and highly significant ($r = -0.91$).

Myers (1943) demonstrated that the frequency of metaphase I univalents is affected significantly by some factor or factors other than chiasma frequency. Similarly, Myers and Hill (1943) found that the increase in incidence of unpaired chromosomes at metaphase I in inbred line 48(48) could not be attributed to fewer chiasmata. In general, however, chiasma frequency is associated with meiotic regularity. This relationship together with the complete synapsis of most tetraploids, suggests that precocious disjunction of loosely held configurations at early metaphase I may contribute to the number of univalents observed at this stage. Since plants differ significantly with respect to meiotic regularity this phenomenon must be partially controlled by genotype.

Myers (1943) found that the frequency of metaphase I univalents was closely related to subsequent irregularities. The behavior of hexaploids was similar to that described for tetraploids, but the hexaploids and some inbred tetraploids also showed univalents in appreciable numbers at diakinesis. Chromosomal differentiation and competition for pairing may be of major significance in determining the presence of univalents at diakinesis. It is also possible that in hexaploids and some inbred tetraploids, the timing mechanism could be interfered with to such an extent that pairing is delayed, and/or precocious disjunction occurs at an earlier stage, as well as just prior to spindle formation.

The frequency of aneuploid plants found in hexaploid progenies approached the values reported by Müntzing (1937) for tetraploid orchard grass, but was substantially lower than the 40 per cent found in open-pollinated populations by Myers and Hill (1940). As mentioned by Myers and Hill (1940) the parentage of the plants studied is an important factor governing the frequency of aneuploids. Thus, Myers and Hill (Unpub.) and Hill (Unpub.) found that the frequency of aneuploids varied from 5 to 27

per cent in the progenies of euploid plants, while the frequency ranged from 6 to 60 per cent in progenies derived from aneuploid plants (2n = 29). All of the plants in the present experiment were euploid (2n = 42), and for that reason might be expected to show less variation than random collections. Under natural conditions hexaploidy did not constitute a truly effective barrier to intercrossing with tetraploid types.

SUMMARY

1. The meiotic behavior of hexaploid orchard grass was studied and compared with the behavior of tetraploid progenies carrying a reciprocal translocation and with the meiotic behavior of tetraploids as reported elsewhere.

2. Correlation coefficients calculated for meiotic irregularities, in the hexaploids indicated that the pattern of irregularity was similar to that of tetraploids, especially inbreds which show a high degree of irregularity.

3. Precocious disjunction is suggested as a factor influencing meiotic regularity.

4. The percentage of aneuploidy in the hexaploid progenies ranged from 0 to 33 per cent, while approximately 11 per cent of the plants examined resulted from intercrossing with adjacent tetraploids.

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VOL. 80, NO. 2, PP. 123–130 MARCH, 1953

VEGETATION OF A RAISED BOG NEAR ITASCA PARK, MINNESOTA[1]

MURRAY F. BUELL AND WILLIAM A. NIERING

Upland stands dominated by balsam fir (*Abies balsamea*) occur in Itasca Park, Minnesota and vicinity. Paper birch (*Betula papyrifera*), white spruce (*Picea glauca*) and often black spruce (*Picea mariana*) are associated with the balsam fir. Lee (1924) considered this community to form the climax matrix. One would expect to find localities rather commonly where fir and spruce have been persisting for several generations. However, examination of fir-spruce stands reveals that those sites where fir and spruce have succeeded themselves are rare compared with the extensiveness of the fir-spruce stands in the area. Sites where they do seem to have been present for a long time are in lowlands, especially along mature bog margins. The stand described in this paper is a small one in which the species appear to have been reproducing themselves for more than one generation. Although the community is on a hillside, it is not truly an upland stand. It occupies a bog with a sloping surface and in doing so exhibits characteristics common to both upland forests and mature lowland bog forests. Recent logging has destroyed a large part of the original fir-spruce stand leaving only the remnant described here.

The bog which the fir-spruce community occupies is a raised bog which has been developed as a result of cold seepage water from a hillside. In addition the north-facing exposure has favored bog formation. These conditions have undoubtedly helped to protect the fir and spruce from fire damage. The bog is of further interest because contiguous with the fir-spruce stand is a younger stage in the development of the seepage bog which is occupied by tamarack, an earlier stage in the succession. This paper presents a description of the bog including the two communities and a discussion of their relationships as contrasted with similar communities of lowland bogs.

Few raised bogs have been studied in central North America. All result from seepage water. Rigg (1940) states that Iron Springs bog near Itasca Park, Minnesota is the only "raised sphagnum bog" that he has seen in the interior of the continent. It is not far from the bog described in this paper. Friesner and Potzger (1946) have described a raised bog in Indiana which originated in part as a low moor bog. Their study included both a detailed

[1] This paper is a contribution from the University of Minnesota Biological Station, Itasca Park and from the Botany Department of Rutgers, the State University of New Jersey.

peat profile and a pollen analysis. Gordon (1933) described a similar bog in Ohio.

The location of the bog described in this paper is on the south side of Sucker Brook where it makes a curve against a steep, curving hillside facing north. The stream marks the lower limit of the bog; the upper limit is about two thirds of the way to the top of the slope. The ridge above consists of coarse, sandy material and at the time of recent lumbering operations was occupied by a forest of jack pine (*Pinus banksiana*). The location specifically is N.W. Section 33, T 144N, R 36 W.

The authors are indebted to Dr. Richard Evans for assistance in the identification of the mosses.

Methods. The vegetation was studied by means of four transects, one of which ran parallel with the stream and through the center of the area. This main transect consisted of a continuous strip ten meters wide and sixty-five meters long. Diameters of all standing trees were recorded by species and all saplings counted. Tree cover was determined along three lines, the two margins and the center line of the 10-meter strip transect. The line intercept method was used (Buell and Cantlon 1950). Tree seedlings were counted on the one-half by two meter quadrats which were used for studying the herb layer. Heights of trees were determined with the Abney level. Shrub cover was obtained by the line intercept method (Bauer 1943). The herb layer was sampled on one-half by two meter quadrats located at five meter intervals along the two margins and along the center line of the ten meter strip. Percent herb cover by species was estimated as well as percent of the layer not occupied by herbs. Percent moss cover was also estimated on these quadrats. It was recorded separately for the few mosses that formed large and distinct colonies but the remainder were recorded simply as "mosses." This latter group is largely characterized by species that occur in mixed assemblages on stumps and logs. The vegetation was also measured along three lines running from the stream up over the bog. These were located at the east end, the middle and the west end of the 10 meter strip. Similar vegetation data, though somewhat less complete, were obtained along them. Collections were made of the species that occurred in the quadrats as well as others noticed on the bog. Nomenclature for vascular plants is according to Gray's Manual, eighth edition (Fernald 1950), and for mosses according to Grout (1940). Peat borings with the Davis sampler were made along the three lines from the stream up across the bog. Notes were made in the field describing the peat. A soil sample was also obtained from the hillside immediately above the bog and its mechanical analysis was determined by the Bouyoucos (1936) method.

Using the Abney level surface profiles were run along the transect lines.

Results. The surface topography and underlying deposits. The surface at the eastern end of the area is like a small plateau with an abrupt drop

toward the stream. It is occupied by spruce and fir. The western portion is lower and slopes uniformly to the stream. It is much wetter and less firm and is occupied predominantly by tamarack (*Larix laricina*). Within and about fifteen meters above the stream there is a clear flowing spring (fig. 1).

The underlying peat deposit, built up as a seepage bog, forms an excrescence on the hillside. Its growth is responsible for the topography described above (fig. 1). At the eastern end it grew most rapidly and appears to have

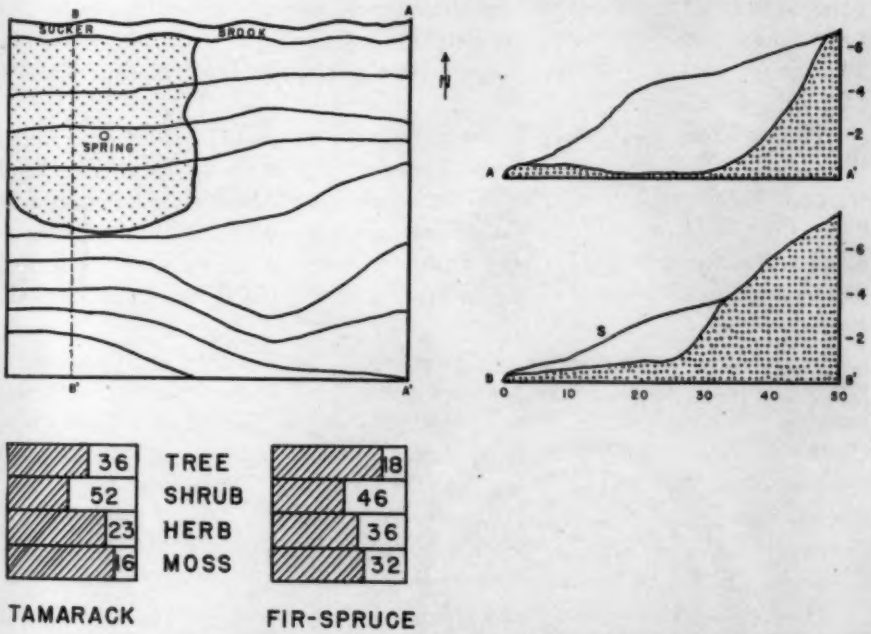

FIG. 1. *Upper left*, map of the bog area studied. The tamarack stand stippled, the fir-spruce stand unshaded. Contour interval is 3 ft. *Upper right*, profiles of the bog along lines AA′ and BB′ of map. Both horizontal and vertical scale in meters. S in the profile BB′ indicates location of the spring. At *lower left* are cover diagrams for the layers of the two stands. Shaded portion of each bar represents cover of the layer indicated. Unshaded portion represents space unoccupied in each layer, the figures indicating the percent of such unoccupied space.

reached a relatively stable condition. There, where the bog has grown most, the peat has attained a depth of fourteen feet. At the bottom is coarse sand intermixed with shells. The overlying deposit consists of alternating layers of woody peat, sedge peat and marl with shells to within one foot of the surface. The top foot is composed primarily of woody forest peat.

In the portion now occupied by the tamaracks the underlying deposits are considerably shallower with a maximum depth of about seven feet. Sand is overlain by alternating layers of woody peat, sedge peat, and marl with shells. The top few inches has marl mixed with abundant moss, herbs, and remains of woody material. The surface is wet and soft.

The pH ranges from 7.5 in the predominantly woody peat to 9.0 in the marl layers at the bottom of the profile. The adjacent upland, formerly forested by jack pine, is of coarse sand. Mechanical analysis of soil taken just above the bog showed 86.4% sand, 9.5% silt, and 4.0% clay.

Vegetation. The tamarack zone. In the lower, wetter area tamarack is the dominant tree, with fir and black and white spruce all present. Tamarack is represented by both large and small trees, while fir and spruce are present as smaller trees. The largest tamarack present was found to be 12.4 inches d.b.h (diameter at breast height) and approximately 112 years old. The canopy is relatively open—open space in the tree layer measuring 36% (fig. 1).

The shrub layer is also open, the heavier growth in this layer being under the open spaces in the tree canopy. There is 52% of the space in this layer which is unoccupied by shrubs. Of the shrub cover *Alnus rugosa* contributes 67%, *Cornus stolonifera* 13% and *Acer spicatum* 11%. Eight other shrub species present contribute a very minor part to the shrub cover. Principal among them are *Rhamnus alnifolia, Ribes americanum, R. triste* and *Prunus virginiana.*

Reflecting the openness of the tree and the shrub layers is the comparatively high herb cover. In the herb layer the space unoccupied by herbs was estimated to be only 23%. *Aralia nudicaulis* was estimated as covering 8%, *Caltha palustris* and *Mitella nuda* each 4% and *Galium triflorum, Thalictrum dioicum,* and *Rubus pubescens* about 1% each. Forty-nine other species each contribute less than 1% cover. Conspicuous among the latter are *Cornus canadensis, Galium triflorum, Impatiens capensis, Viola pallens, Calamagrostis canadensis* and *Carex* spp.

The moss layer has a higher cover than the herb layer, there being but 16% unoccupied. *Mnium* (principally *M. cuspidatum* and *M. medium*) is the most important moss genus with a cover of 55%. *Sphagnum* with 8% cover is second and *Thuidium delicatulum* third. The rest of the moss layer consists of a miscellany of species often growing intermingled on logs and stumps. One percent of the quadrat space was occupied by fallen and rotting logs.

The fir-spruce zone. The fir is the dominant tree in the drier portion of the bog. Associated with the fir in order of their importance as mature trees are black spruce, white spruce, paper birch and tamarack. The average height of the forest is fifty feet with occasional white spruce towering ten feet or more above the other species. Fir is well distributed through the size classes from seedlings to mature trees (13.8 inches d.b.h., the maximum). The spruces are also reproducing. White spruce is most abundant in the smaller-size classes. In contrast, the black spruce is primarily represented in the larger size classes. The oldest spruces are much older than the firs, the maximum age of the fir being about fifty years; that of the spruces,

FIG. 2. View of fir-spruce stand from the tamarack stand. Young spruce trees are in the foreground, a branch of a tamarack overhead and mature firs and spruces in the background. Notice dead and broken trees characteristic of the climax forest community.

which are of comparable diameters, is about 145 years. The forest canopy is much more continuous than that of the tamarack (figs. 1–2). Open space in the canopy is about eighteen percent, one-half that of the tamarack area.

The shrub layer has 46% of its area unoccupied. Of the shrub cover *Acer spicatum* supplies 56%, *Alnus rugosa* 23% and *Cornus stolonifera* 7%.

It is noteworthy that the order of importance of *Acer* and *Alnus* is the reverse of that in the tamarack area. There are nine other species of shrubs but all of them are of minor importance in their contribution to cover.

The amount of open space in the herb layer was estimated as about 36%. It is characterized by considerable diversity, only one species, *Aralia nudicaulis* was estimated as contributing as much as 7% to the cover, and five species, *Mitella nuda, Cornus canadensis, Rubus pubescens, Thalictrum dioicum* and *Caltha palustris* 1 to 2% cover. Sixty-seven other species have an average cover of less than 1% each.

Although the moss layer is high in cover, there being but 32% of the layer unoccupied, it is not as high as the tamarack area which has only 16% unoccupied by mosses. *Mnium* covers 31% of the area, *Thuidium delicatulum* 9% and *Sphagnum* 7%. *Caliergonella schreberi* and *Hypnum cristacastrensis* are the only other mosses recorded with an average of 1% or over. There are mixed aggregations on stumps and logs and hummocks which together contribute 17% to the cover in this layer. Fallen logs are common and occupy 6% of the quadrat areas.

Stream margin. The vegetation changes rapidly as the stream margin is approached. The peat deposit is shallow with mineral soil close to the surface. Tall white spruce up to 72 feet high characterize the area. The herb and shrub strata are poor in typical fir-spruce woodland species, while there is an increase in species which reflect the increased light at the open stream and the relatively shallow humus layer.

Discussion. There are two points of especial interest that come out of the study of this seepage bog. The first is the succession on such a bog as compared with succession on the typical low moor type of undrained depressions. The second is the apparent pronounced effects of climatic change on the bog condition.

Succession on the bog has certain similarities with that of the typical low moor bog of the vicinity. A community with tamarack dominant represents an early stage in the succession. The tamarack stage is a relatively open woodland with alder dominating the shrub layer and with a high herb cover. The structure in this respect is not unlike the tamarack stage in the low moor bog succession. However, in two respects it is markedly different. The ground surface does not have the well developed mounds and depressions typical of the low moor tamarack stands. Secondly the principal moss genus is *Mnium*, with sphagnum secondary, the reverse of the situation in the low moor bog. The study also indicates that the tamarack community may be followed directly by a community of spruces, both black and white, and fir rather than one predominantly of black spruce. Seedlings and saplings of both the species of spruce and the fir occur in the tamarack zone.

The fir-spruce stand on the higher level of the bog has the characteristics of a climax community, since all mature species are represented in the

smaller-size classes. However change in proportional composition may be anticipated, since the white spruce seedlings are twice as numerous as those of black spruce. Furthermore there are eleven times as many fir seedlings as white spruce and hence the fir may be expected not only to maintain its dominance but even to increase it. Conway (1949) has suggested that on many bogs of this region the succession "may end by carrying an *Abies balsamea* climax similar to that so widely occurring in the northern coniferous forest region." An *Abies* dominated community certainly appears to be the probable climax on this seepage bog excrescent on its north-facing slope. In fact the already established spruce-fir stand is quite similar to the climax coniferous forest described by Cooper for Isle Royale (Cooper 1913). The black spruce present here is not a member of Cooper's upland climax. However, as already mentioned, it is decreasing in the community. The succession does not appear to lead to a fir-black ash-elm climax which Kell (1938) suggested for peat soils in the Itasca Park area.

Pronounced differences between this seepage bog and bogs of depressions are to be expected. Bogs of depressions are subject to annual floodings while the sloping surface of this bog precludes such. This may in part explain such phenomena as fir and spruce together succeeding tamarack. Or the explanation in this case may be more involved. Succession on a seepage bog may be due to two things: first the build-up of the bog by the accumulation of peat. This is well illustrated on the higher portion where a climax is now essentially established. The second cause of succession may be a climatic change toward a drier condition. Such a change would both reduce the seepage rate and increase evaporation. The bog would thus become drier. The fir-spruce then would be favored and would invade the tamarack. Succession by this cause would be more abrupt than through the physiographic growth of the deposit.

To some extent depression bogs respond to climatic moisture cycles by settling or rising with changing water tables (Buell & Buell 1941). However, Conway (1949) has shown that such cycles have decided effects on vegetation sufficient to allow one to interpret recent climatic cycles. This being true of bogs of depressions, then such a seepage bog as the one described here may also have been a good recorder of major postglacial climatic cycles, since the existence of the seepage bog is dependent upon the maintenance of both the seepage rate and a low evaporation rate. A climatic shift would act on both in a complementary fashion, regardless of which way the climate should swing. A drier climate would accelerate the succession; but if the change were toward the wetter climate, a retrogression might occur with the fir and spruce yielding to an open tamarack forest accompanied by the accumulation of more marl and sedge peat. The profile suggests that this has occurred. Both the fir-spruce portion and the tamarack area revealed alternating layers of different kinds of deposit: marl, sedge peat, and woody peat.

In Europe profiles of such raised bogs have contributed to interpretation of climatic changes, as illustrated by Conway's (1947) study of Ringinglow Bog near Sheffield, England. Further study of such seepage bogs in central North America may yield detailed information on horizons that will be subject to climatic interpretations in the same way.

SUMMARY

1. A raised bog fed by seepage water from a north-facing hillside is occupied by two stands, one dominated by tamarack and the other by fir and spruce.

2. The succession from tamarack to fir-spruce is evident and is similar to that of low moors.

3. Certain details of both succession and community structure are different from those of low moor bogs and are apparently due to the sloping, drained surface. These differences are greatest in the lowest strata of the communities.

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TETRAPLOID SMOOTH BROMEGRASS[1]

IRVING WILLIAM KNOBLOCH

The chromosome number of *Bromus inermis* Leyss has been investigated by a number of workers (Avdulov 1928, 1931; Cugnac & Simonet 1941; Elliott & Wilsie 1948; Hill & Myers 1948; Nielsen 1939; Stählin 1929a, 1929b) and although the octoploid number of 56 is most commonly encountered, hexaploids and decaploids are known. During the course of a series of investigations (Knobloch 1943, 1944) on the species in 1941 and 1942 at Iowa State College, some plants were found to display the tetraploid number ($2N = 4X = 28$) in their root tip cells.

Materials and methods. Two plants of bromegrass were utilized in the present study. These were designated 554-39 and 554-49 and were part of the open-pollinated progeny of seed lot P-173 obtained from the Soil Conservation Service at Pullman, Washington, and grown at the Iowa State Agricultural Experiment Station. Seeds from these two original plants were germinated at East Lansing and the resulting plants form the basis of the present study.

The root tips, in most cases, were pretreated by immersion for from nine to twelve hours in an aqueous solution of actidione, 100 parts per million. This treatment was advantageous in shortening the rather long chromosomes found in smooth bromegrass. Actidione is a cyclohexamine and was obtained from the Upjohn Company through the courtesy of Dr. John Vaughn of the Botany and Plant Pathology Department of Michigan State College. The tips were next killed and fixed in Carnoy's solution and stored in 70% alcohol. Smears were made from this material and stained by either the Feulgen technique or with Belling's aceto-carmine. Some root tips were processed by the usual methods and embedded in paraffin. Crystal violet was the stain used on this material.

Results. The tetraploid plants which were studied appeared less vigorous and flowered somewhat later than did the normal octoploid plants as seen in figure 1. Their pollen grains were noticeably smaller (figs. 2a and 2b) but otherwise seemed normal in appearance.

Plant 554-39

Figure 3 demonstrates the chromosome configuration in an untreated root tip cell of this plant. This should be compared with figure 4 where the

[1] Contribution No. 23 from the Department of Biological Science and Paper No. 1282 from the Agricultural Experiment Station, Michigan State College. The advice and aid of Dr. G. Bernard Wilson is deeply appreciated.

FIG. 1. Differences in flowering; octoploid left, tetraploid right.

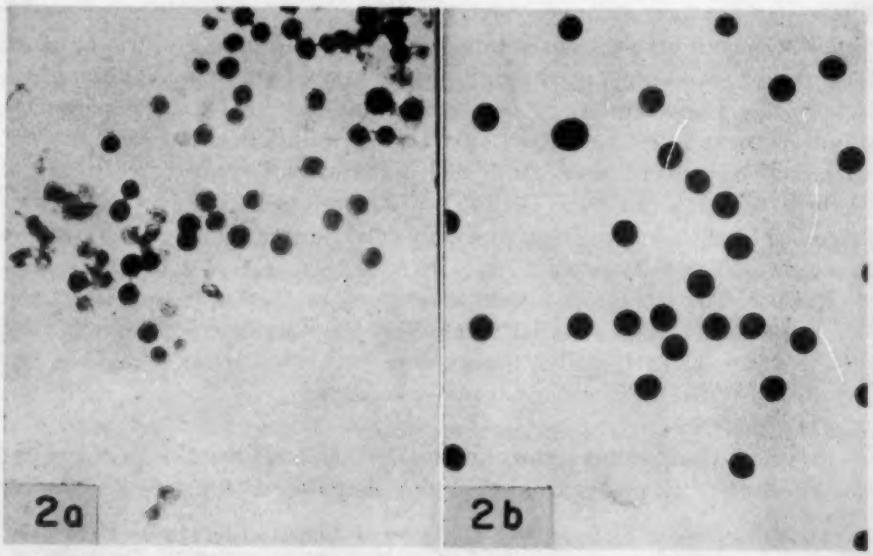

FIG. 2a, pollen from tetraploid. 45 × Ca. Fig. 2b, pollen from octoploid. 45 × Ca.

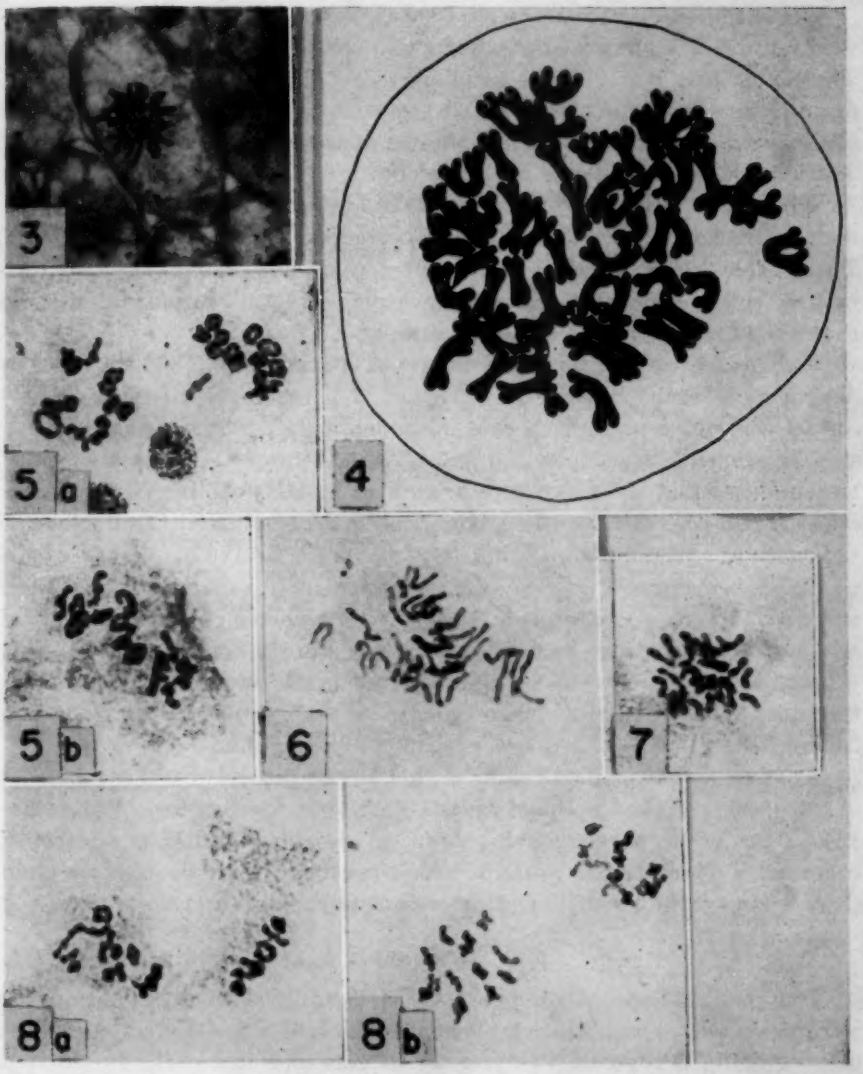

FIG. 3, root tip cell of 554-39, 900 × Ca. FIG. 4, root tip cell of an octoploid, 3157 × Ca. FIGS. 5a & 5b, pollen mother cells of 554-39, 750 × Ca. FIG. 6, root tip cell of 554-49, 1500 × Ca. FIG. 7, root tip cell of 554-49, actidione-treated, 750 × Ca. FIGS. 8a & 8b, pollen mother cells of 554-49, 750 × Ca.

octoploid condition is shown. This octoploid cell is from the root tip of a plant of another clone growing nearby. The meiotic chromosomes of 554-39 are shown in figures 5a and 5b. Both open and closed rings are common and the 14 bivalents can be observed with a fair degree of accuracy. Pairing appears to be completely regular.

Plant 554-49

Figure 6 is a picture of the tetraploid complement in the root tip cells. The contracting power of the actidione is not shown here so well as it is in figure 7, derived from a root tip of the same plant. The meiotic picture is similar to that of the preceding plant and is shown in figures 8a and 8b. There are apparently fewer ring bivalents.

Discussion. Elliott and Wilsie (1948) reported on similar bromegrass material recently. Their 554-39 was reported as a polyhaploid with 2n = 28. Their Table 2 lists 554-49 as being an octoploid but their figure 12 shows a root tip complement of 28 for this same plant. It can be assumed, however, that 554-49 is meant to be called an octoploid.

The present report lists both plants as being tetraploids. The apparent discrepancy can be explained by the fact that the genetical constitution of 554-49 was different in each case inasmuch as the plants, from which the seed originated, were open-pollinated. The theoretical importance of the tetraploids is that they may have originated by the doubling of the chromosomes in some ancestral diploid. They may have originated through somatic reduction of an octoploid. A number of plants are said to display this reduction phenomenon such as *Solanum nigrum gigas* (Winkler 1922), *Freesia*, Improved Purity (Brittingham 1934), *Allium cepa* (Huskins 1948), *Trillium sessile*, *T. ovatum* and *T. erectum* (Wilson and Cheng 1949), *Rhoeo* (Huskins and Steinitz 1948), and *Hieracium Hoppeanum* (Christov and Christov 1948). However, since pairing is perfect and quadrivalents are lacking, the plants studied are probably allotetraploids.

Another aspect of importance is that the tetraploid may have been one of the parents of the hexaploid investigated by the writer earlier (Knobloch 1943), the other parent having been an octoploid. Although tetraploid bromegrass plants enter anthesis somewhat later than do the octoploids, there is always the possibility of precocious tetraploids and tardy octoploids.

SUMMARY

Two plants of smooth bromegrass, 554-39 and 554-49, are reported to be tetraploids with a somatic complement of 28 and a meiotic set of 14 bivalents. Pairing is regular. The possible origins and one of the functions of the tetraploid are discussed.

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THALICTRUM CARDENASIANUM SP. N.[1]

BERNARD BOIVIN

The study of the following new species of *Thalictrum* brings out more clearly the close relationsihp of *T. inuncans* Boivin and *T. venturii* Boivin. In my monograph,[2] these two species were placed far apart, but their possible relationship was pointed out and this relationship is now more evident since a third species of the section *Camptogastrum* is now known to have, like the above two, perfect flowers, obtuse or truncate anthers and slightly clavate stigmas. Of course, there are other species of the same section that seem to have perfect flowers, but this is certain only for *T. inuncans, T. venturii,* and *T. cardenasianum*. The doubt is due to the fact that the staminate flowers often appear much later than the perfect ones. As some species are represented by a small number of sheets, there is often doubt as to whether a species has only perfect flowers or whether the various phases of the plant have simply not all been collected.

Due to this incertainty, it is not yet advisable to place the three aforementioned species in a separate section or subsection, but there seems to be no doubt as to their close relationship. My key of the section *Camptogastrum* (Rhodora **46**: 400. 1944) may be modified to begin as follows:

Stigmas slightly clavate, obtuse at tip. Flowers perfect. Anthers obtuse or truncate, never apiculate.
  Plant pubescent and rugose due to the presence of tiny prickles. Filaments 15–17 mm long. Stigma 6–11 mm long ..... *T. inuncans*
  Plant glabrous. Filaments less than 10 mm long.
    Stigma 2.5–6 mm long.
      Ovaries 18 to 36 per flower. Filaments yellowish ..... *T. venturii*
      Ovaries 8 to 16 per flower. Filaments deep purple ..... *T. cardenasianum*
Stigmas finely attenuate at tip, thickest towards the base or the middle. Flowers usually polygamomonoecious. Anthers more or less apiculate ..... *Camptogastra coetera*

Thalictrum cardenasianum sp. n. *Planta* metralis forsan saepius 40–60 cm subvirgata omnio glabra. *Folia* caulinaria pauca petiolata quater ternata. *Petiolus* ramis conspicue divaricatis et paullum incurvatis estipellulatis. *Foliolae* saepius 5–10 mm long., tenues, inferne pallidiores et apice trilobatae. *Folia* inflorescentiae pauca sessilia et ad ter ternata coeteris consimilia. *Inflorescentia* corymbosa. *Pedunculi* 1.5–2.0 cm. *Flores* omnes perfecti. *Tepala* parva viridula ca 1.5 mm long. *Stamina* ± 8 in flore. *Filamenta*

[1] Contribution No. 1159 from the Division of Botany and Plant Pathology, Science Service, Department of Agriculture, Ottawa, Canada.

[2] Rhodora **46**: 337–377, 391–445, 453–487. 1944.

tenua debilia violaceo-splendentia ca 8 mm. *Antherae* ca 2.5 mm oblongo-lineares, apice truncatae, viridulae et ± purpuracentes. *Ovaria* 8–16 in flore. *Stigma* 3.0–3.5 mm, flexuosum atro-violaceum, paullo clavatum, cum apice rotundo. *Carpella* submatura viridula reflexa, 2.5–3.0 mm long., ventro ovoideo, stipite minimo. *Nervi* 4 in fructu, in costis elevati, sinuosi, ventralis quam dorsali convexior. Floret martio. An februario etiam?

Bolivia, Cochabamba: *M. Cardenas 3934*, Liriuni, alt. 2570 m, at the shade of bushes in wet soil, height 40–60 cm, flowers green, III–1947 (Gray Herbarium, type).

Although the collector describes the plant as being 40 to 60 centimeters high, the specimen at hand measures 103 cm from the base of the stem to the top of the corymb.

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A SECOND SPECIES OF SCHISMOCARPUS

JULIAN A. STEYERMARK

Schismocarpus matudai Steyermark, sp. nov. Planta aut cum floribus aut cum foliis; caule cum foliis 12 cm. alto; foliis alternis petiolatis, laminis membranaceis elliptico-oblongis subobtusis vel acuminatis 15–22 cm. longis 4–7 cm. latis obscure inequaliterque crenulato-serratis supra inaequaliter setoso-scabridis subtus pallidioribus magis hispidulis, nervis utroque latere 8–13 arcuato-adscendentibus, petiolis 1.3–5 cm. longis parce vel moderatim hispidulis; caule cum floribus dense hispidulo: panicula terminali, floribus nonnulli densiuscule aggregatis; calycis tubo obconico 2 mm. alto utrinque hispidulo; calycis lobis anguste lanceolatis 3 mm. longis medio 1 mm. latis utrinque hispidulis; petalis elliptico-oblongis apice acutis 13 mm. longis 5 mm. latis; staminibus 10 omnibus antheriferis, antisepalis longioribus, 5 eorum 3 mm. longis 5 eorum 6 mm. longis; stylo 9 mm. longo; stigmate-capitato.

Type (flowering plant) in Matuda herb., collected in Mexico: Chiapas: on wet rocks, in mixed woods, along Río Cintalapa, between Jilguero and Piñuela in municipality of Escuintla, about 32 km. northeast of Escuintla, alt. about 500 m., *Matuda 5330.*

Cotype (vegetative plant) in herb. Chi. Nat. Hist. Herb., collected on wet bushy rock, shaded river bank, flowering without leaves, Piñuela, N.E. Escuintla, Chiapas, Mexico, alt. 400 m., May 25, 1951, *K. Nakamura 41* and *E. Matuda 26086.*

The genus *Schismocarpus* was originally described by Blake (Contr. Gray Herb. **53**: 62–63. 1918) with one species, *S. pachypus,* known from the state of Oaxaca, Mexico.

The second species of the genus has been discovered in the state of Chiapas by the discriminating botanist, Mr. Eizi Matuda, for whom it is a pleasure to name the species. It differs from *S. pachypus* in the larger acute petals, more densely hispidulous stem and branches of the inflorescence of the flowering plant, and more densely flowered inflorescences.

CHICAGO NATURAL HISTORY MUSEUM

AND

MISSOURI BOTANICAL GARDEN

BULLETIN OF THE TORREY BOTANICAL CLUB

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TORREYA

BOOK REVIEWS

Nuttall's Travels into the Old Northwest. An unpublished 1810 Diary. Edited by Jeannette E. Graustein. 88 pages; figs. 1–5; 8 plates; map. The Chronica Botanica Co., Waltham, Mass. $3.00.

Thomas Nuttall was probably the most important of the early botanical explorers of North America; in the extent and difficulty of his travels, the value of his collections, and the scientific soundness of his published work, few have excelled him. The story of his life has been well described in recent years; this hitherto unpublished diary fills in one of the few remaining gaps in our knowledge.

At the instance of Benjamin Smith Barton, Nuttall, in his third year in America, undertook a preposterous expedition to the region of Lake Winnipeg, without regard to climate, wilderness, Indians, or the British. He left Philadelphia April 12, 1810, going first to Pittsburgh by coach, thence on foot to Erie. He wandered along the shores of Lake Erie to Sandusky, where he took boat for Detroit. From Detroit he went by canoe to Michilimackinac. Here the record ends (save for a few fragmentary entries obviously added much later). It must have been here that he realized the impossibility of carrying out the projected visit to Lake Winnipeg. It was certainly here that he had the good fortune to fall in with the Astorian expedition bound for the headwaters of the Missouri. The rest of the story is well known from other sources.

To us who roll rapidly over the same country on paved highways, the difficulties of a lonely traveler of those days are hard to visualize. "On arriving at Le Boeuf I had the heart felt mortification to learn that my trunk owing to the lowness of creek might not be at this place in a month & that when at Erie it might remain there for a vessel as much longer. Finding no other alternative I determined to return back to Franklin & if no means offered of conveying it on immediately I determined to carry the contents of the trunk on my back weak as I was." The weakness was caused by malaria. "I was detained in Franklin, using every effort to recover myself of this ague. I tried bleeding ineffectually as little or no blood could be obtained from me; I tried an emetic but it did not operate in a large dose; I then tried calomel & jalap, which acted as a violent emetic, which I stood much in need of." "To day I again betook myself to my unfortunate journey but I was very weak & unfit for what I had undertaken, the day was very warm, & I was uncommonly burthened having to carry the contents of my trunk upon my back & my gun in my hand thus situated I could make but little progress. On my way I saw a species of *Asclepias*, which was new to me the leaves were in 4.s verticillate, ovali-lanc. acuminate; roseaceous & odorous." Ill and weary as he was, he did not fail to notice the plants along the way and to write down a description which enables us to recognize *Asclepias quadrifolia*. That devotion to natural history which afterwards earned him the appellation of "le fou" from his fellow travelers is evident in every page of the diary. It is filled with descriptions so accurate that the species can be determined (their names are supplied in footnotes by the editor). Although plants were his greatest interest, he had eyes also for animals and rocks. He made one side-trip to see the "petroleum springs" on the Allegheny. "After proceeding up the creek about 2 miles I came to the springs, which are on the banks of the creek. They dig shallow pits for the purpose, thro' the water of which the petroleum slowly rises to the surface; . . . In a favourable season they obtain from 3 to 4 barrels of 32 gallons each yearly. It is the same substance which is sold under the name of British oil it is here much esteemed for scalds & burns, also for rheumatism & in fact for almost anything." Anything, I suppose, except heating buildings and transporting us over land and water and through the air. At Sandusky he saw his first prairies and wondered at their extent;

he was to see much more of them. He has much to say of the goitre prevalent in the region of Detroit. Here also he met his first Indians. "We saw and conversed with a number of Chippeway Indians, who were very poor & almost destitute of any kind of provision except a little sturgeon, and they are likely to remain so, as they have such an aversion to agricultural labour, at the same time that their animal food becomes continually scarcer we saw here a considerable band, yet they had scarcely 2 acres of maize."

Dr. Graustein is to be congratulated on her careful editing and abundant and informative notes. She has also provided a preliminary sketch of Nuttall's life, and several appendices, including lists of animals and plants. An index would have been useful. A number of illustrations from contemporary prints embellish the book—portraits of Barton and of Nuttall, and views of the Missouri River, of Indians, and other subjects more or less related to Nuttall's travels.—H. W. RICKETT

Ferns of Michigan. By Cecil Billington. viii + 240 pp., including 17 plates of half-tones, 81 line cuts, 101 state distribution maps, 9 page pictorial glossary. Cranbrook Institute of Science, Bloomfield Hills, Mich. 1952. $5.00.

This important addition to the list of state "Fern Books" is the product of several authors, due to the death of Mr. Billington, who had laid aside his manuscript in order that the book might adopt the nomenclature of the eighth edition of Gray's Manual. Chief among the contributors is Dr. Stanley Cain, who has succeeded admirably in carrying out Mr. Billington's aim as expressed in his preface: ". . . to arrive at a happy medium between the formal botanical manuals and the strictly popular works".

Probably the most distinctive feature of the book is its comprehensive nature—not until page 65 does the subject matter deal with Michigan ferns and fern allies as such. The earlier chapters cover a wide range of topics such as life-history, folklore, utilization, culture of ferns from the spore up, collecting and identification. The section on utilization contains several debatable topics, such as the wholesale gathering of fern fronds for decorative purposes. Your reviewer was so surprised by reading on page 18 that "when burned, the ashes of the Bracken make a valuable manure, having a high nitrogen content" that he referred the matter to colleagues, who reported that "high nitrogen content" appears to be entirely in error. The "pictorial glossary" is a prominent feature, and the striking photographs of sori (magnification not indicated) by Charles Neidorf should be very useful.

In the descriptive part of the book, keys of the usual dichotomous type are provided; although they are not "indented" this does not appear to be a real drawback, in view of the small number of entities concerned. The treatment of each species consists of paragraphs on: description, habitat, range in North America and briefly in other continents in case the range is wide, distribution in Michigan with discussion of doubtful records, and finally some remarks on features of special interest—here is the place where an author's own observations and opinions naturally find an outlet. An excellent line drawing of a leaf or whole plant, and a map showing distribution by counties accompany each section. These maps represent part of Dr. Cain's work on the project.

As might be expected from the projection of the "Upper Peninsula" into Lake Superior, the fern flora of the state shows a definite Arctic element, quite in contrast with the cool temperate denizens of the southern counties. The maps partly bring out the "unusually large number of examples of disjunctive distribution" (p. 167). The range of the hay-scented fern (*Dennstaedtia punctilobula*) furnishes a challenging case. A comparative table shows that Michigan contains 72% of the genera, 64% of the species and 48% of the separate entities in Gray's Manual. It appears that comparatively little attention has been given in Michigan to fern hybrids. Perusal of the index indicates that it has been carefully prepared, but would in the opinion of the reviewer be definitely improved by printing in italics or bold-faced type the principal reference to each fern. Although "Ferns of Michigan" ranks as a "bulletin" of the Cranbrook Institute of Science, it is a handsome, well-bound book of 248 pages, worthy of a place on the shelf of every student of ferns.—M. A. CHRYSLER, Rutgers University.

Introductory Mycology. By Constantine John Alexopoulos. xiii + 482 pages; figs. 1–187. John Wiley and Sons, New York; Chapman and Hall, London. 1952. $7.00.

This book will be welcomed by a great many college and university teachers who have sought in vain for a textbook adequate for a one-term course in Mycology. The available texts on the fungi are overburdened, almost without exception, by attempts to include consideration of the immense variability which the fungi possess. This volume by Dr. Alexopoulos avoids that pitfall, for, in his words, it is "not a complete treatise on the fungi, and is not intended as a reference book." The author has succeeded in presenting an orderly arrangement of the facts "without the innumerable details and exceptions which make the study of fungi so fascinating for the specialist, but so bewildering for the beginner." It meets the requirements for an introductory course based on comparative morphology (structure and life history). In addition to its use in the classroom, this book should offer to the interested amateur an insight into the general morphology and life cycles of the fungi in a more lucid manner than any other text generally available.

The introductory chapter deals with the general terms and concepts encountered in studying the fungi, bacteria, and slime molds. Terms which the student meets for the first time are printed in boldface, and are defined; the etymology of the terms is also given. These terms are again defined in a glossary at the end of the book. The second chapter covers the bacteria, and the third, the slime molds. Four chapters are devoted to the Phycomycetes, five to the Ascomycetes, one to the Deuteromycetes, and three to the Basidiomycetes. Finally, the lichens are summarily treated in a two-page chapter.

The classification which has been followed is conservative, and no new rearrangements are proposed. It is, indeed, a bit disconcerting to find that no apparent attempt has been made to follow the rules of nomenclature. Species citations such as *Phyllactinia corylea* (Pers.) Karst., *Geoglossum ophioglossoides* (L.) Wint., and *Fomes applanatus* (Pers.) Gill. abound in the legends of the figures (figs. 96, 121, 171). These are doubtless the result of the author's attempt to follow one or more of the outstanding authorities in the citation of authors; in the text proper, however, author citations are not included, and it may have been preferable to leave them off the legends, avoiding the perpetuation of such citations.

If one can find any complaint in regard to this work, it must lie in the fact that much of the material is necessarily "predigested" for the student. But the inclusion of the many excellent life history diagrams cannot be considered as a concession to the lazy student. No other text has attempted to present such a comprehensive series of diagrams; these will be invaluable to the student in organizing his thinking in regard to the many types of life cycle which occur in the fungi. The diagrams, almost without exception, are quite clear, and usually indicate the haplophase, diplophase, and, where present, the dikaryophase. Two of the life histories have been printed on thin paper folds (figs. 102, 156), presumably because they offered difficulty in organization onto a two-page spread such as was done with certain others (figs. 46, 112). A reduction in the size of the drawings and some rearrangement of the parts would have obviated the awkward folding pages which so easily become creased or torn in the hands of the student. Perhaps in future editions this handicap will be overcome, even at the expense of some crowding of the figures (as in figs. 85, 119). In addition to the life cycles, a great many figures are provided illustrating general morphology. Many are wholly new drawings, while others have been redrawn. The artist, Mrs. Sun Huang Sung, is to be complimented on the clarity of the figures, which eliminate, where possible, extraneous or confusing details. Many well-chosen photographs are included as well.

The treatments accorded the various groups differ greatly in their length. In a one-term course, only a certain amount of material can be discussed, and the arrangement of the book clearly indicates this. The Allantosphaeriaceae and the Xylariaceae, for example, each receive but a short paragraph; the Microthyriales, only three and a

half lines. Were this book intended as a source book for the student, such a treatment would be clearly inadequate. On the other hand, the book contains clear and detailed descriptions of the morphology and life histories of certain carefully selected genera and species. From these examples the student should obtain a background for further studies and for more extensive treatments in later courses.

Clear and simple keys to the various groups are dispersed throughout the chapters. Following each chapter is a list of selected references which should be of value in leading the more industrious student to the pertinent literature. A good index is also provided.

Dr. Alexopoulos is to be commended heartily for supplying so definite a need in mycological textbooks.—RICHARD P. KORF, Cornell University.

Laboratory Manual for Introductory Mycology. By Const. J. Alexopoulos and E. S. Beneke. iv + 177 pages; plates 1–17. Burgess Publishing Company, Minneapolis. 1952.

This manual is intended as a guide to the laboratory work in the introductory course in Mycology at Michigan State College. Its value to teachers in other institutions will depend in part upon the emphasis which these teachers will wish to give to certain groups of the fungi, bacteria, and slime molds. The amount of material which is covered is greater than that which could be conveniently covered in a one-term course in many institutions. This will allow the instructor to select from the manual those portions which are best adapted to his own course outline. In most cases, the representatives of the various groups which have been chosen for class study are readily available to Mycology instructors in this country.

The manual is divided into two parts, the first covering methods useful in the study of fungi, the second treating the various groups according to the classification. The section on methods (apparently intended for student reference, and not for specific laboratory sessions) is clearly written, and will prove valuable to the student not yet acquainted with the laboratory manipulations necessary for a study of the fungi.

The various laboratory outlines begin with general remarks on the group under consideration, and follow with rather detailed instructions as to the procedure to be followed in a study of the material. A series of often penetrating questions follows each exercise, which should test the student's grasp of the subject matter. New terms which have been introduced in the general remarks or procedure sections are defined at the end of each outline. These definitions are indexed in a glossary at the end of the manual.

At the close of each outline references are provided to the treatments given in the two general texts used by the writers, Alexopoulos' INTRODUCTORY MYCOLOGY and Bessey's MORPHOLOGY AND TAXONOMY OF FUNGI. These are followed by a valuable list of selected references, including many of the more recent or critical papers which have appeared on the groups.

A number of large, but quite diagrammatic, drawings by Mrs. Sun Huang Sung illustrate the general morphological features of the various groups, and elucidate some of the more confusing or difficult terminology. There are a rather large number of minor typographical errors, which will doubtless be corrected in future editions.

Because of the nature of the book, it seems doubtful whether it can be adapted for general use as a laboratory outline in many of the courses on Mycology being offered in our colleges and universities. It will, however, be of value to the teachers of such courses in offering them ideas for the improvement of their own laboratory class work. —R. P. K.

FIELD TRIP REPORTS

Sept. 21. Van Cortlandt Park, Bronx, N. Y. Lichens, wildflowers, shrubs, trees, and migrating birds were studied with the helpful assistance of Mr. William Rissanen and Mr. Joseph Monachino. Attendance 15. Leader, Jane Meyer.

Oct. 3, 4, 5. Delaware Water Gap, Pa. This, our only Pennsylvania outing of 1952,

might be considered an adjourned session of the Sussex County Nature Conference since the idea originated there, too late for the field schedule. It was staged by those professionals, Mr. and Mrs. Wallace Husk, Mr. James Hawley, Louis Hand, and our field chairman—David Fables. Friday afternoon and evening were devoted to registration, reunion, and gossip—more scientifically called "accounts of summer activities of members".

On Saturday morning a combined bird and plant hike was taken to the hills in back of the Hotel Delaware Water Gap, our headquarters. Asters and goldenrods competed with an immature red-crossbill and a red-breasted nuthatch. After lunch the group took the Appalachian Trail up Mt. Minsi. Botanical features were rhododendrons around Lake Lenape, hemlock (too many across the Trail), rusty woodsia, rock Selaginella, and autumn coral-root. The extraordinary vistas and broad views of the landscape of the Water Gap compensated for the dearth of hawks in flight. The evening feature was an illustrated lecture on the British Isles based upon a recent trip by the speaker, Mr. D'Arcy Northwood.

Fringed gentians were found Sunday en route to Bushkill Falls, where additional plants of the season were studied along with enjoying and photographing the scenery. Attendance 55.

Oct. 5. Southern Middlesex County, N. J. Stops were made to see examples of the following: 1) an upland forest, 2) abandoned fields of various ages, 3) depression areas and the surrounding ridge.

The upland forest consisted mainly of beech, white-oak, scarlet oak, and black birch. The shrub layer was chiefly maple-leaved viburnum. Several species of aster were in fruit. Abandoned fields of one year, three years, ten years, and thirty-five years were seen. In the one year-old field which had been plowed the previous July, lesser ragweed was the dominant plant. In the three year-old field species of goldenrod were dominant, while ragweed was almost absent. In the ten year-old field broom-sedge was the dominant, with several young bayberry plants present. The thirty-five year old field, which had been an apple orchard before abandonment, showed broom-sedge as the dominant herb, with several patches of bayberry and low-bush blueberry scattered throughout. Remains of apple trees could frequently be seen in these patches. Trees present in the field included white oak, scrub oak, pin oak, and pitch pine. In the depression area, which is a low undrained region, *Panicum verrucosum* was abundant. As one went from the depression to the higher and drier surrounding region, the dominant trees successively were red-maple, pin oak, black oak, and white oak. Numerous chestnut stumps were noticed. The shrub layer was composed chiefly of *Vaccinium* sp. and sweet pepper-bush. Large patches of the common lady's-slipper and the whorled pogonia were seen. Attendance 5. Leader, Julius Cohn.

* * *

Oct. 11. Flood Plain of the Manasquan River, N. J. The day was pleasant and the company, tho small, was good, so "a good time was had by all." Charley lost himself but managed to find us in time for lunch.

There were some beautiful *Gentiana Saponaria* right at the edge of the road near the meeting place. We saw the site of old marl pits and some outcroppings of the marl along the river. We found a few specimens of *Staphylea trifolia* and *Evonymus americanus* in the low land. The ox bow bends were observed and commented on as were the large trees both standing and fallen. At Allenwood Mrs. Snodgrass entertained us with a Gloriosa (climbing spider lily) in full bloom.

We left the Manasquan basin and went to the Hannah Brand Brook which is a tributary of Wreck Pond. Here we found two medium sized trees of *Castanea dentata* that had survived the blight and we picked up a few nuts. Along the same brook was a magnificent stand of *Spiranthes*. There were hundreds of them, *praecox* and *cernua* mixed. Attendance 12. Leader, V. L. Frazee.

Oct. 12. Greenbrook Sanctuary in the New Jersey section of the Palisades Interstate Park. Participants saw part of the areas where research is being carried on in

connection with the Palisades Nature Association fellowship. Stations for maximum and minimum recording thermometers were examined for weekly temperature extremes at various stops. Evaporation jars were also located at these stations. Sweet gum was noted as a fairly common tree in damp spots on low ground. The tree approaches the northern limit of its range in this area. Along C Trail wild grape had successfully dominated an area opened by the storm, two years ago. Attendance 16. Leader, Stephen Collins.

Oct. 19. Inwood Park, New York City. This walk was of unusual beauty because of the golden leaves of the large number of Benzoin or spicebushes. Indian caves, potholes, garnets, embedded in schist, were observed as well as trees, shrubs, and wild flowers. Few migrating birds were seen. Attendance 12. Leader, Jane Meyer.

Oct. 26. Watchung Reservation, Union County, N. J. The leader showed us some of his research being carried on under a fellowship provided by the Union County Park Commission. The walk included old field aspects on south facing slope, lowland meadow and thicket, swamp forest in secondary succession, hemlock gorge, deciduous forest on north facing and south facing slopes. The consequences of various degrees of disturbance were pointed out. The study includes both animal and plant relationships. Attendance 16. Leader, James Baird.

Oct. 26. Lebanon State Forest, Burlington and Ocean Counties, N. J. The group assembled at Deep Hollow Pond for lunch while listening to a talk by Dr. Murray Buell, Rutgers University, on the possible ecological implications of prescribed burning and the plans of the Pine Region Hydrological Research Project. The trip included visits to the control-burn plots in the Forest where an interesting discussion developed regarding the effect of fire on soils, plants, and animals. Later, Mr. Henry C. Barksdale explained the U. S. Geological Survey's part in the program and took the group to the newly erected stream-gaging station. The two experimental watersheds were visited and the methods of study outlined. In addition to the agencies above, this project and its fellowship has the interest and support of the local laboratory of the U. S. Forest Service and the Southern New Jersey Development Council. Attendance 51. Leader, Jack McCormick.

NOTES

Professor Charles Lyon of Dartmouth, on leave, has been visiting laboratories in the New York, New Brunswick, Philadelphia area and beyond. Dr. Lyon is contributing to the botanical part of a forthcoming A.I.B.S. Handbook.

Under the title of The New Britton and Brown Illustrated Flora of the Northeastern United States and Adjacent Canada, The New York Botanical Garden has just published a new work in three volumes, with text by Dr. H. A. Gleason and collaborators, and wholly new illustrations. The list price of the Flora is $30.00 (plus $.50 charge for postage and handling from which a 10% discount is granted on orders received before July 1, 1953.

A symposium on the N. J. Pine region, arranged by Section G of the A.A.A.S. and the Ecological Society of America and presented in Philadelphia, December, 1951 appears in the current number of Bartonia, journal of the Philadelphia Botanical Club. The journal may be had for $1.00 from Dr. E. T. Wherry, Univ. of Pennsylvania or covered reprints at the same price, Dr. John A. Small, New Jersey College for Women, New Brunswick, N. J. There are eight papers dealing with soils, pollen profiles, forest practices including prescribed burning, water, and future multiple use possibilities.

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INDEX TO AMERICAN BOTANICAL LITERATURE

COMPILED BY

LAZELLA SCHWARTEN

WITH THE COLLABORATION OF THE EDITORS OF THE TAXONOMIC INDEX

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